Price risk, yield risk and automatic stabilisation of revenues in cash crop smallholder agriculture: the case of Indian pepper growers

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PRICE RISK, YIELD RISK AND AUTOMATIC STABILISATION OF REVENUES IN CASH CROP SMALLHOLDER AGRICULTURE: THE CASE OF INDIAN PEPPER GROWERS

Wouter Zant

ABSTRACT

In this paper we quantify empirically the extent of the price risk, output risk and crop revenue risk for smallholder pepper growers in the south of India. Policies aiming at reduction of revenue risk often focus on either reducing price risk or output risk. Time series estimates suggest that price risk in pepper is high, while survey data on Indian pepper growers show that output risk is of the same order of magnitude. Revenue risk is less than the sum of price and output risk. We formalise the notion of automatic stabilisation, the offsetting movement of price and output. In the case under consideration, automatic stabilisation appears to be very modest. In order to design effective policies for reducing revenue risk of a specific crop one should investigate beforehand the relative size of price and output risk, and – particularly if the country is a large supplier on the world market – the extent of automatic stabilisation.

JEL CODE: Q12

KEY WORDS: commodities, revenue uncertainty, farm households, India

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1. Introduction: price risk and yield risk

In this paper we investigate empirically the extent of the price risk and output or yield risk in the cultivation of pepper in India. The relative size of these risks is important because these risks are the major determinants to revenue uncertainty, and - if crop revenue is important in total income – income uncertainty. A number of recent policy initiatives to reduce the revenue uncertainty of farmers focus on either the price component of revenue risk (see e.g. Gilbert et al. (2001), Gilbert et al. (2002)), or the output component of revenue risk (Skees et al. (2001, 2002); Hess (2003)), using an index insurance technique (Skees et al. (1999)). Measuring the relative size of these risks and assessing the extent of automatic stabilisation appear to be sensible first steps in designing efficient policies.

The price risk component of revenue risk in commodity production is relatively easy to measure on the basis of available (aggregate) time series of growers' prices. Variation of growers' prices, preferably deflated in an appropriate way, adequately reflects the extent of the price risk component of revenue risk. Records of growers' prices are usually maintained by statistical departments of commodity organisations or related governmental organisations, by organised markets or auctions, or even by large processing companies. Most growers' prices are accessible to a wide public at negligible or no cost. If markets are sufficiently transparent, variation in market prices - opposed to growers' prices - may also be an appropriate indicator of price risk for farmers. However, it may be necessary to determine whether the officially published growers' prices are indeed the price which farmers actually receive, since official prices may fail to reflect regional and quality variation.

Output or yield risk is more difficult to measure. Aggregate series on production disguise the variation of production that is experienced by individual pepper growers. Aggregate variation only corresponds with the actual yield risk facing individual growers by chance. Panel data of farm households are required to obtain a measure of the variation of output and yield, and consequently of the potential output and yield risk for growers.

The paper is organised as follows. In Section 2 we present a standard derivation of the cost of uncertainty for farmers following the work of Newbery and Stiglitz (1981). We derive the expressions for the cost of uncertainty in crop production under both price and output (yield) uncertainty and for the case of various sources of income. We discuss the cost of uncertainty if both price and output are uncertain. In Section 3 we give an empirical description of the world pepper market, the position of India on this market, the regional distribution of production, and the development of production and prices within India. In

Section 4 we establish the variation of prices using aggregate data. In Section 5 we explain the source of our survey data and its design and we present descriptive tables and figures characterising the position of Indian pepper growers and we show potential determinants of yield variation. Next, we measure variation of output and yield on the basis of these survey data. We also measure variation in crop revenue and we assess the extent of automatic stabilisation of crop revenue. In order to place revenue uncertainty in perspective, we conclude this section with measuring the variation in consumption expenditure. Section 6 gives the concluding remarks of this exercise.

2. Revenue risk and welfare of crop cultivation

Risk aversion is reflected in the curvature of the utility function. We take the elasticity of marginal utility or the coefficient of relative risk aversion (R) as a measure of risk aversion. The coefficient of relative risk aversion is defined as

$$R(\Pi_t) = - \Pi_t \,.\, U''(\Pi_t) \,/\, U'(\Pi_t) = - \Pi_t \,.\, A(\Pi_t) \qquad (1)$$

where Π_t = farmer income at time t;
U' and U'' indicate the first and second derivative of the utility function
$A(\Pi_t)$ is the coefficient of absolute risk aversion of income Π_t

A Taylor series expansion of the utility of income around a stochastic income variable – specified as the sum of a non-stochastic certainty equivalent income and a stochastic deviation with zero expected value - combined with a Taylor series expansion of certainty equivalent income, shows that we can approximate the risk premium (or the cost of risk) as follows:

$$\text{Cost of risk (absolute level)} \approx \tfrac{1}{2} A(\Pi_t)\, VAR_{t-1}(\Pi_t) \qquad (2)$$

Since it is more useful to express the risk premium - or the cost of risk - as a fraction of mean income, we obtain on the basis of equation (2) and using the identity that the coefficient of relative risk aversion (R) is the product of mean income and the coefficient of absolute risk aversion (A):

$$\text{Cost of risk (relative to mean income)} \approx \tfrac{1}{2} R\, \sigma_\Pi^{\,2} \qquad (3)$$

where $\sigma_\Pi^{\,2}$ is the coefficient of variation of income Π

For the moment we postulate that income is generated from one source, in particular income is equal to revenue from crop cultivation. We are therefore ignoring the important issue of crop and activity diversification. In order to specify the cost of the income risk we need to understand how income comes about. If farmers have only income from crop cultivation, this may be characterised as:

$$\Pi_t = q_t.p_t - \varphi.Z(q_t) \qquad (4)$$

where
q_t = production at time t;
p_t = real growers price at time t;
φ = 1+interest rate;
$Z(.)$ = cost function

For simplicity we assume a simple linear approximation for the cost function, and, hence, equation (4) becomes:

$$\Pi_t = \zeta\, q_t.p_t \qquad (5)$$

A first order approximation to the variance of a product where both production (q_t) and growers' price (p_t) are random but not independent runs as follows (taken from Goodman, (1960)):

$$\begin{aligned} \mathrm{VAR}_{t-1}(\Pi_t) &= \mathrm{VAR}_{t-1}(q_t p_t) = \\ &= \left[\bar{q}^2\, \mathrm{VAR}(q_t) + \bar{p}^2\, \mathrm{VAR}(p_t) + \frac{\mathrm{VAR}(q_t)\mathrm{VAR}(p_t)}{n} + \right. \\ &\quad \frac{\mathrm{COV}[(q_t-\bar{q})^2(q_t-\bar{q})^2] - E_{11}{}^2(2-n)}{n^2} + \\ &\quad \left. \frac{2n\,\bar{q}\,\bar{p}\,E_{11} + 2\,\bar{q}\,\bar{p}\,E_{12} + 2\,\bar{q}\,\bar{p}\,E_{21}}{n} \right] \end{aligned} \qquad (6)$$

where $E_{ij} = E(q_t - \bar{q})^i (q_t - \bar{q})^j$ and
E is the expectation operator and
$\bar{q} = \mathrm{mean}(q_t)$ and $\bar{p} = \mathrm{mean}(p_t)$

The calculation of the coefficient of variation is straightforward, by dividing the variance with the squared mean, in this case $p(mean)^2.q(mean)^2$, and hence omitted. The last two terms in equation (6) disappear if prices and production are independent. The dependence of the variance on these terms determines the quantitative size of automatic stabilisation, i.e. the potential impact on the variance of the opposite movement of price and output. Consequently, the important lesson to learn from this expression is that the variance of crop revenue is partly determined by the covariance between production and price. This covariance is most likely to be negative, particularly if the country is a large supplier on the world market. The covariance between production and price establishes a potential and automatic mechanism that reduces revenue risk. The exact size of the automatic stabilisation will differ by country, across commodities and over time and is an empirical matter. We will investigate this for the case of Indian pepper growers.

We may also extend the original expression (equation (3)) to the case of income from various sources, i.e. not only income from one crop but also income from other crops, and income from activities outside agriculture (wage income, property income, remittances, processing, etc). Income can be written as the sum of income from various sources:

$$\Pi_t = \Sigma\, \pi_{i,t} \tag{7}$$

and the variance of income is written as:

$$VAR_{t-1}(\Pi_t) = VAR_{t-1}(\Sigma\, \pi_{i,t}) = \Sigma\, VAR_{t-1}\, \pi_{i,t} + 2\, \Sigma\, COV_{t-1}(\pi_{i,t} \,.\, \pi_{j,t}) \quad \text{with } i \neq j \tag{8}$$

where i = source of income

Again, and as in the previous derivation, it is more useful to express all components of this equation independent of the unit of measurement. After some manipulation of this expression we derive

$$\sigma^2(\Pi) \approx \Sigma\, \alpha_i\ \sigma^2(\pi_i) + 2.\, \Sigma\, [\beta_{ij}\ \rho(\pi_i, \pi_j)] \qquad \text{with } i \neq j \tag{9}$$

where $\alpha_i = [avg(\pi_{i,t}) / avg(\Pi_t)]^2$

$\beta_{ij} = \sigma(\pi_i).\sigma(\pi_j) / avg(\Pi_t)^2$ with $i \neq j$

$\sigma(\pi_i)$ is the standard deviation of income i

$\rho(\pi_i, \pi_j)$ is the coefficient of correlation between income i and income j

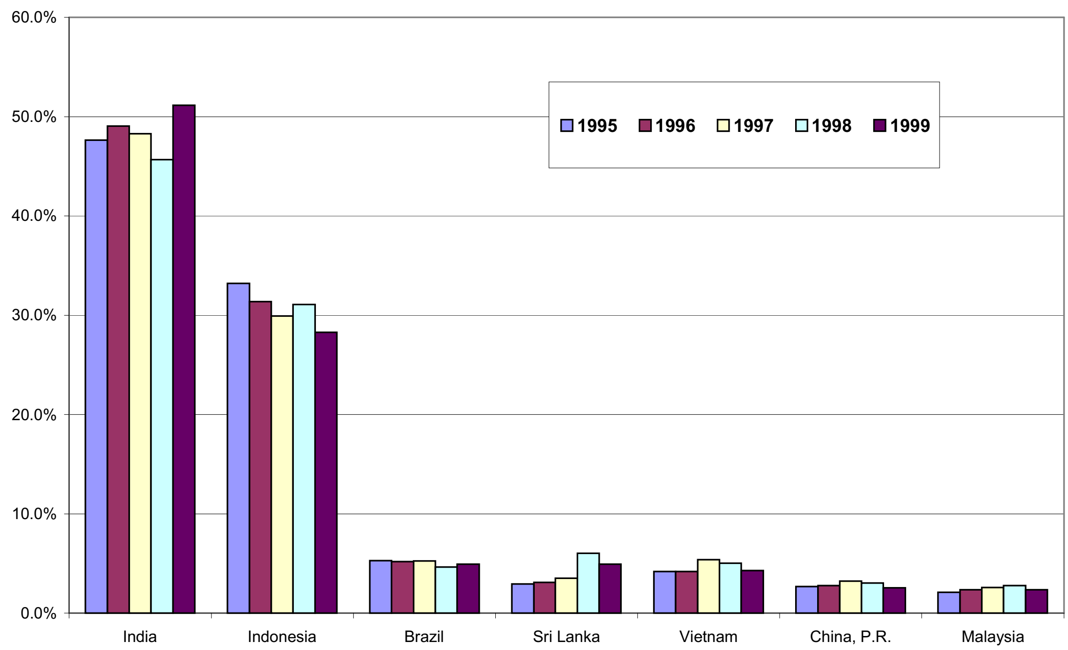
Equation (9) establishes that in the case of various sources of income, risk reduction may be brought about through the correlation of these sources of income (see also Newbery and Stiglitz (1981), p88). In order to be beneficial in terms of risk reduction, it is (only) required for diversification, either in other crops or in other income earning activities, that not all correlations are equal to one[1]. Our micro data identify various sources of income and hence allow analysis of the risk reducing contribution of the various income components. However, this is beyond the scope of the current investigation.

3. Pepper cultivation in India

India is a large producer of pepper (see Figure 1). Indonesia is the only other producer with a major share of world production. However, recently Vietnam has experienced substantial growth in production and an increase of its share on the world market. World production in 1999 is estimated at around 170 thousand tons. India accounts for 75 thousand tons.

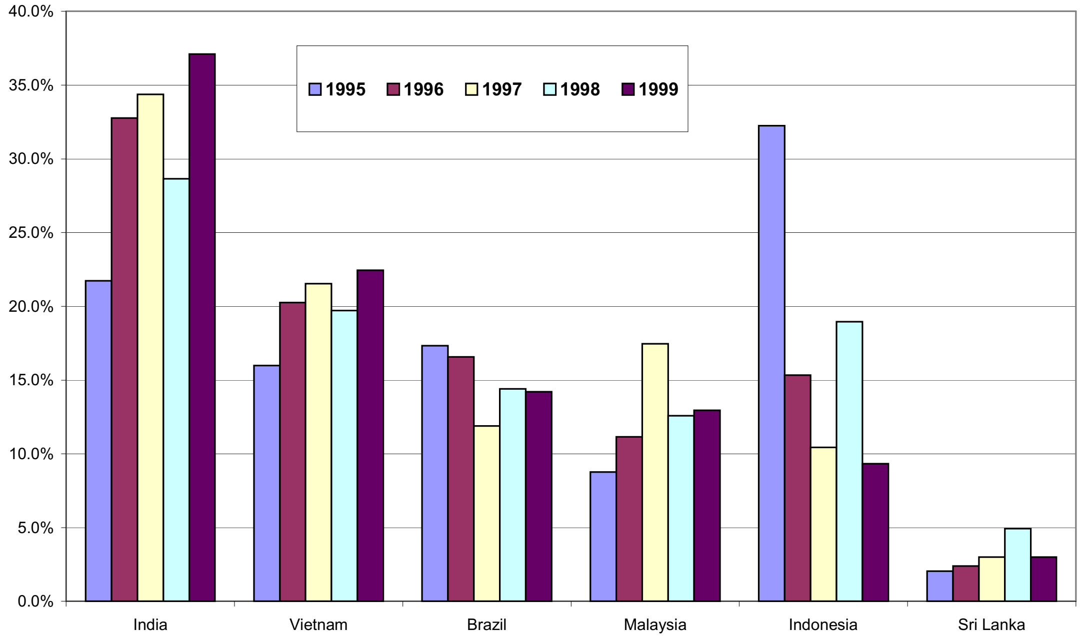
Due to large domestic consumption within India (30 thousand tons) and within Indonesia, the distribution of export shares diverges from the distribution of production. Export shares are shown in Figure 2. From Figure 2 it is observed that Brazil, Vietnam and Malaysia are major pepper exporters in the world, after India and Indonesia.

Figure 1 Production of black pepper: share in world production (source: IPC)



[1] This is a well known result obtained from the Markowitz portfolio selection model and can be found in any standard finance textbook.

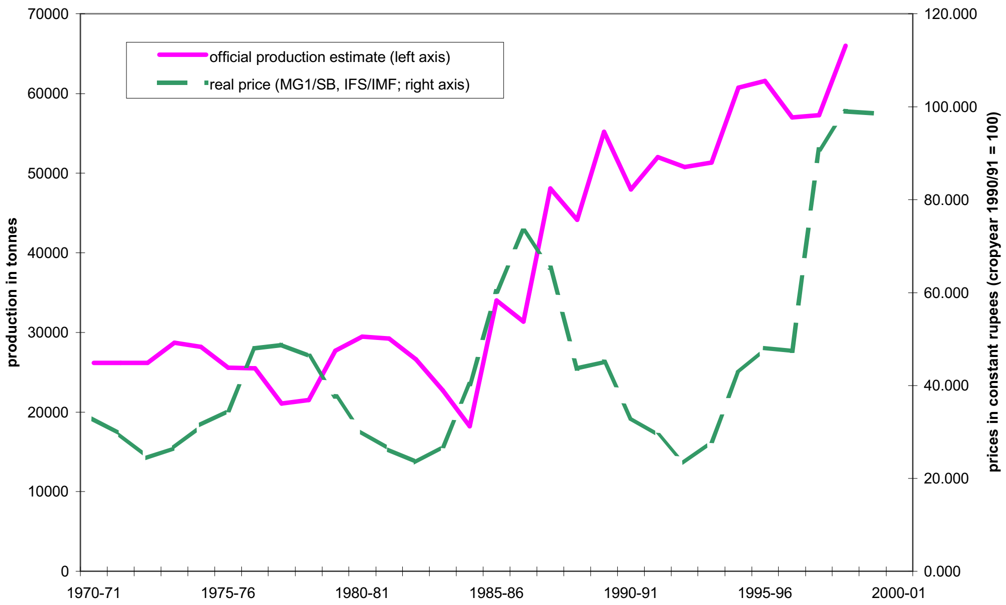
Figure 2 Exports of black pepper: share in total export (source: IPC)



Within India pepper production is largely concentrated in the south, particularly in the state of Kerala. Traditionally, two districts within Kerala, Idukki and Wayanad, account for two third of all production, while the remaining one third originates from other parts of Kerala. Nevertheless, in recent years pepper cultivation has become increasingly prevalent in the state of Karnataka and since the prospects for growth of area under pepper are better in this state, there has been some shift in the geographical distribution of pepper production within India in and this is likely to continue.

The development of pepper production and real prices of pepper in India is shown in Figure 3. Prices of pepper (Malabar Garbled, grade 1 at Cochin market) are deflated by the Indian consumer price index, obtained from the International Financial Statistics of the IMF. The figure shows three clear hikes in real prices (1976/77-1978/79, 1986/87-1987/88 and 1997/98-1999/2000). The difference in real price between a peak and a low may be large: e.g. real prices during the recent peak price period (from 1997/98 to 1999/2000), are more than 3.5 times as high relative to real prices during the preceding low price period 1991/92-1993/94. The figure also suggests that the price hike in the 1980s has boosted production of pepper. The lack of downward adjustment of production after the subsequent decrease in prices underscores the perennial crop character of supply of pepper: once pepper vines are planted and productive, farmers are reluctant to cut down these pepper vines, even if prices and returns decrease drastically.

Figure 3 Production and prices of Indian pepper (annual data, crop years, 1970/71-2000/01)



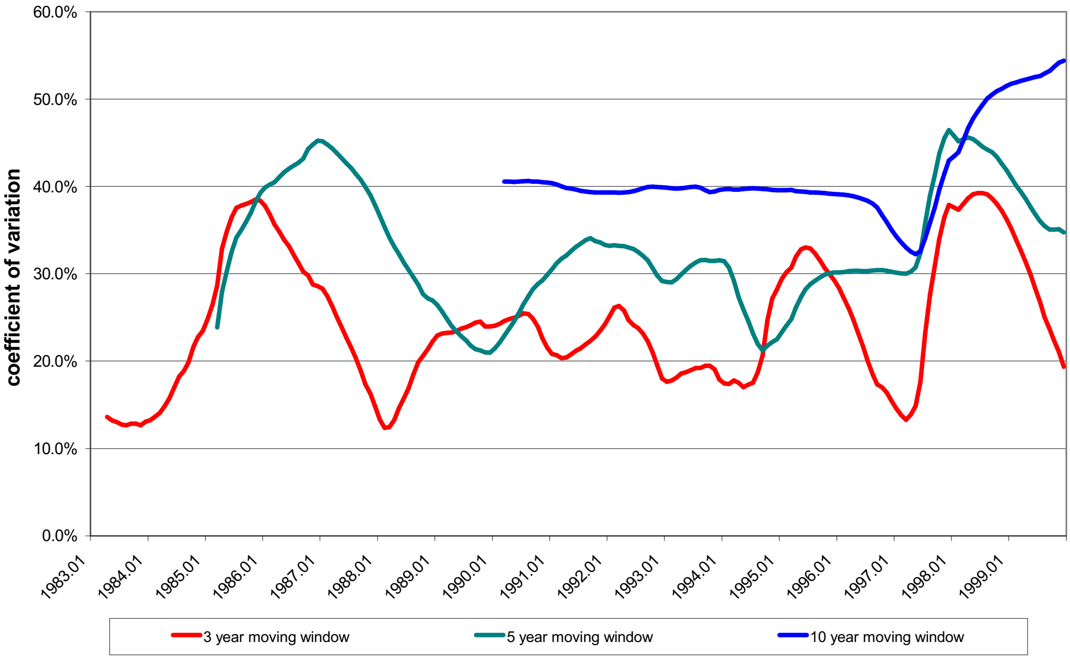
4. Macro evidence of price risk

With the help of aggregate or macro data on growers' prices one may simply calculate the extent of the price risk by calculating the variation of prices. If markets are sufficiently transparent it is unlikely that growers' prices diverge substantially and in a random way from export prices or world market prices. If, for example, growers' prices are continuously, say around 5% below market prices e.g. due to transportation costs, their respective CVs will be identical. In the south of India growers' prices of pepper appear to follow market prices quite accurately, mainly because pepper growers have contacts with the large traders and exporters in Cochin, the major export harbour through local traders and middlemen[2]. Hence, in order to get a reasonable quantitative measure of the price risk in pepper cultivation in India, we calculated variation of monthly average prices of black pepper at the Cochin market, so-called MG-1 (Malabar Garbled, grade 1), deflated with the Indian consumer price index

[2] We have compared official monthly market prices of pepper with averaged per kg sales values from our survey. These survey based monthly averages often contain few observations, since households in the survey do not sell their harvested pepper in each month of the year, but usually only during a limited number months. This also prevents estimation of official prices on growers' price obtained from the survey. However, visual inspection of these 'averaged' series suggests that prices received by farmers closely follow officially recorded market prices (see appendix). Hence, we may conclude that village and local markets are integrated with the world market.

(International Financial Statistics, IMF). In order to measure the variation of prices we have chosen the coefficient of variation (CV) since the CV is a dimensionless measure and hence comparable with CVs calculated for other prices, and because it nicely fits in the calculation of the costs of risk, as set out in the section above[3].

Figure 4 Coefficient of variation of price of pepper: macro evidence (monthly data, January 1980 - December 1999)



The CV over the complete sample period (January 1980-December 1999) has a value close to 50%. The extent of the price risk may change over time, due to structural changes that have taken place over the years. One example of this is the economic and trade liberalisation that has taken place at the start of the 1990s. This suggests measurement of price variation based on smaller sample periods. Figure 4 shows the coefficient of variation with a moving window of resp. 3, 5 and 10 year. From the figure it is observed that the CV of prices fluctuates between 10 and 55%. The CV with a 10 year moving window has a relatively stable value of around 40%, and increases to a value above 50% at the end of the 1990s. Such values of the coefficient of variation indicate a high price risk (for comparison one may calculate the CV of price for other commodities (see e.g. Newbery and Stiglitz (1981) for the period 1950-1974 on the basis of annual data and values ranging from 14.7% to 109.1%; most likely these values have changed in the

[3] Another dimensionless (and popular measure) of variation is the variance of relative price changes: in the appendix we have calculated this measure using the same data as used for Figure 4.

mean time since many countries have liberalised their economies which may have affected price variation).

We are particularly interested in investigating production risk for farmers, and from this perspective, it is not useful to calculate coefficient of variation of production on the basis of aggregate time series data of production. Since these data aggregate the production of a large number of growers and since increases and decreases in production offset each other, a considerable part of fluctuation of output or yield is disguised in these series. Measuring output or yield risk on the basis of aggregate national production data is, hence, unhelpful.

5. Micro evidence of yield risk and crop revenue risk

5.1. Survey design and data description

In order to assess the extent of yield risk we focus in the remainder of this paper on micro data since these data are clearly superior to macro data for our specific purpose. In particular we exploit data from a representative survey, undertaken at the end of the 1990s and the start of 2000[4]. The core data used in this paper cover two complete crop years (1998-99 and 1999-2000) and originate from both annual and monthly surveys. During this period households in the sample were interviewed on a monthly basis. Further we have used recall data for three additional crop years (1995-96, 1996-97 and 1997-98). The sample contains data on 250 pepper growers. The sample is taken from a larger representative sample of 2500 farmers[5] and the 250 observations have been distributed among the blocks - the lowest strata identified for our estimation - proportionate to the number of pepper vines in each block.

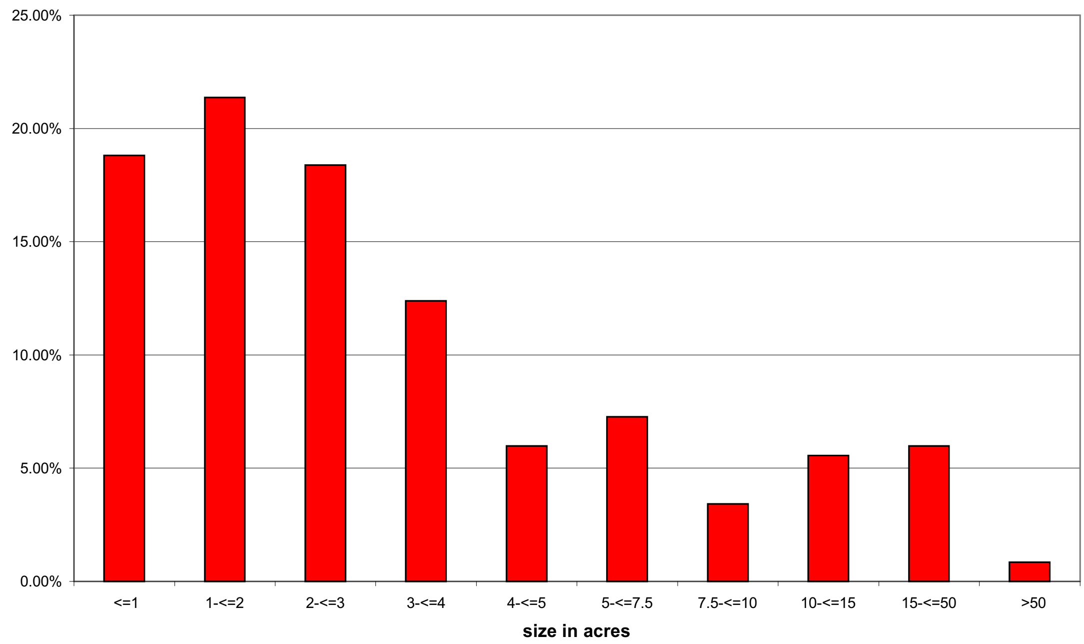
Pepper is a perennial crop: the pepper vine that winds along a support tree, bears fruit after 3-5 years and reaches an average age of 20-25 years. The crop is grown under a wide range of conditions in terms of plant variety, support tree, altitude, soil, mode of cultivation (mono, mixed, homestead), scale of production, crop combinations, rainfall, sunshine, humidity, use of inputs, etc. The crop season starts in April. In the south of India the monsoon sets in June and extends to August. Depending on the area, harvesting takes place from December to March. In the season 1998-1999 and 1999-2000 Kerala accounted for around 60-75% of total Indian production, and within Kerala the bulk of

[4]The survey data have been collected and compiled by the Spices Board of India, Cochin and the Economic and Social Institute of the Free University, Amsterdam. Financial support from the Indo Dutch Program on Alternative Developments (IDPAD) is kindly acknowledged.

this pepper production (around 40-60%) originates from the higher districts of Idukki and Wayanad[6]. The larger share of area under pepper in the south of India pertains to mixed cropping cultivation (Kerala close to 90%, Karnataka, 77% and Tamil Nadu close to 100%). The major crop combinations under pepper growers in Kerala is pepper, coconut and arecanut or plantain, and in Karnataka (and the district of Wayanad in Kerala) pepper, coffee and arecanut or cardamom.

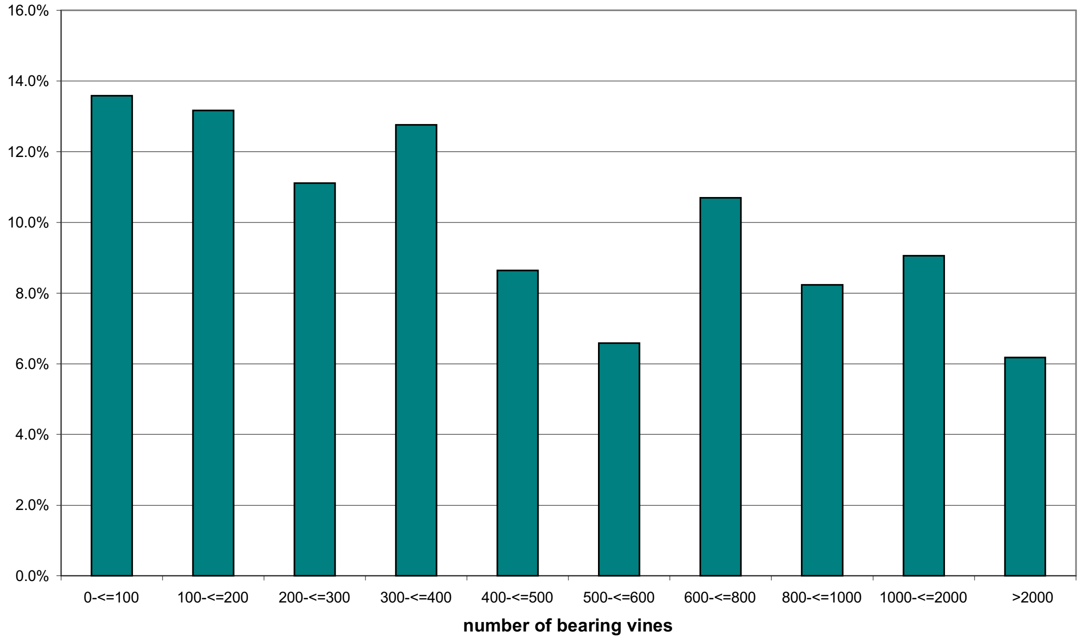
The prevalence of mixed cropping, with a variety of crops, but also planted with a variety of densities, make it virtually impossible to determine the area share of each crop. Data on total holding size are, however, available. With weighted average (and median) total holding size of 4.7 (2.4) acres[7], holdings of pepper growers are small. The distribution of holdings by size (see Figure 5) indicates that close to 60% of Indian pepper growers have holdings sizes of less than 3 acres

Figure 5 Distribution of holding sizes of pepper growers



[5] For a discussion of the design of this survey, see Cheriankunju et al. (1999a).
[6] Reliable figures of production of pepper are hard to obtain. The quoted figures are own calculations reported in Cheriankunju et al. (1999a,b), where the measurement of production of Indian pepper is specifically addressed.

Figure 6 Distribution of number of bearing vines per growers



Since data on pepper area are conceptually problematic due to differing cropping system (mixed cropping, mono cropping, homestead cultivation) and due to the wide range of densities in pepper cultivation, the number of stands is proposed as an alternative in the calculation of yields. Data on the number of stands (vines) are less ambiguous than data on area under pepper. The distribution of the number of bearing vines per household is shown in Figure 6 and in the Appendix a cross tabulation of total holding size and number of bearing vines is given. The figures above and the table in the appendix confirm that the larger part of growers has small holdings and most growers derive a significant share of their agricultural income from pepper[8].

Yield risk in pepper cultivation takes various forms. The most important risk in this respect relates to the quantity of rainfall during the growing season. Both excess rainfall and drought give rise to poor harvests, though in varying degrees and with different underlying mechanisms. Elsewhere an attempt is made to quantify the relationship between rainfall during the growing season and yield per vine (see Zant et al. (1999)). One of the results of this work is shown in Figure 7. The impact of rainfall on yield per vine is quantified with the help of a multivariate regression of the yield per vine on a wide variety of variables (e.g. use of fertiliser, labour, and other inputs, age of vines, type of soil, variety of pepper vines, etc.). The figure shows a positive relationship

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[7] One acre equals 0.4047 hectare or, equivalently, 1 hectare ≈ 2.5 acres.
[8] The table in the appendix shows that there are few large holdings with few vines.

between the yield per vine and excess rainfall that dies out, both at very high and very low levels of (excess) rainfall (below 500 mm below normal or above 900 mm above normal).

Figure 7 Yield per vine and rainfall

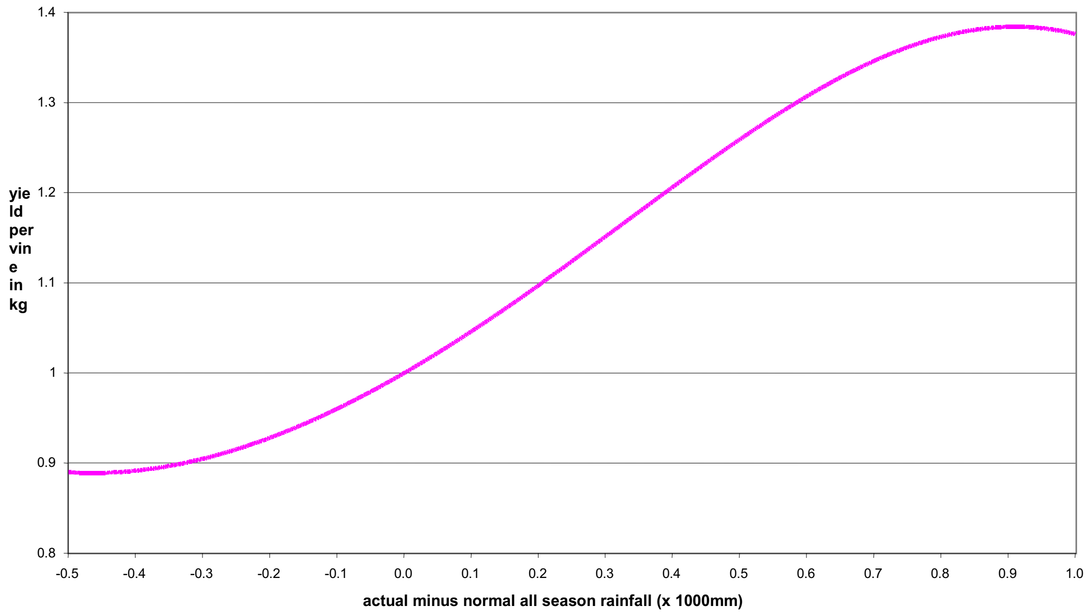
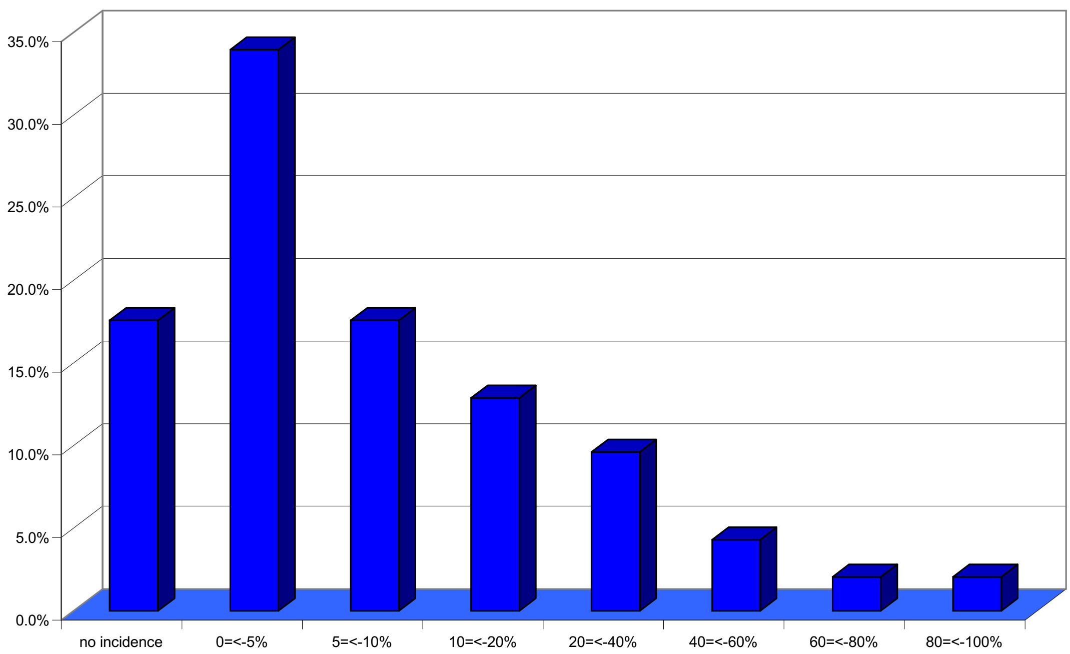


Figure 8 Rate of incidence of diseases in Indian pepper cultivation



A significant and quantitatively important relationship between rainfall and yield per vine combined with a high yield or output risk suggests the potential for insuring these risks through rainfall derivatives (see e.g. Skees et al. (2002)).

The frequency distribution is this incidence rate is shown in Figure 8. The figure suggests a sizable adverse impact of diseases on the stock of vines and, hence, on pepper production: more than 30% of all pepper growers have an incidence rate of 10% or higher. The average incidence rate is 14%. Incidence of disease appears to be higher on holdings with larger sizes.

5.2. Variation in output in pepper cultivation

In the discussion on the impact of uncertainty on welfare in Section 3 we saw that decisions of farm household are influenced by two factors, namely the coefficient of risk aversion and the square of the coefficient of variation (CV). Within the mean variance framework welfare is linearly dependent on the square of the CV and, hence, the CV is an appropriate indicator to quantify risk.

In Table 1 coefficients of variation are presented for output of pepper growers. On the basis of survey data we have calculated the coefficient of variation of yield for each individual farmer using production of 5 distinct crop years (namely 1995-96 to 1999-2000), and, next, we have averaged these farmer specific CV's over the complete sample. Hence, we make use of the variation of yield of each individual pepper grower separately ('within' variation). 'Between' variation - variation in yields between different growers - is much larger, in the order of 80-90%. However, this between variation is to a large extent explained by differences between growers (soil, type of cultivation, varieties, altitude, support tree, size of plot, irrigation, drainage). It is most likely that this variation is entirely incorporated in the behaviour of farmers – it is non-stochastic – and, hence, it does not reflect yield risk. Since the coefficients of variation are calculated for each grower separately, the calculation of CV's automatically controls for these ((un)observable) fixed effects.

The median is also calculated in order to control for extreme and non-representative values of the CV, and for skewness of the distribution[9]. Another correction pertains to changes in the number of vines: yields may rise substantially from one year to another due to new planting or due to vines reaching the bearing stage. This variation in yield, however, has little relation with yield or output risk. Hence, we control for this by running the calculations for yield per (bearing) vine. Table 1 also reports weighted and

[9] In the appendix a histogram of the frequency distribution of the coefficient of variation of output is shown.

unweighted values of CV's. In the remainder we limit the discussion of the results to unweighted CV's since weighted and un-weighted CV's do not diverge fundamentally.

Table 1

Coefficient of variation of output and output per vine: Micro evidence

	OUTPUT	**OUTPUT PER VINE**
Unweighted		
Average	45.1% (0.017)	48.2% (0.017)
Median	39.7% (0.014)	40.7% (0.013)
Weighted	45.0% (0.021)	50.3% (0.045)

Bootstrapped standard deviation in brackets next to the CVs; number of households: 250; number of crop years: 5 (1995-1996 to 1999-2000; Source: Spices Board India, Cochin and ESI-VU, Amsterdam, The Netherlands

From Table 1 it is clear that the values of the CV are relatively high: though variation in pepper prices is of the same order of magnitude, other empirical studies clearly suggest that such values are extreme (see for example Newbery and Stiglitz (1981) and references listed in Chapter 7 of N&S). The high level of the coefficient of variation of yield or output is interesting in itself. Even if fluctuations in output are sufficiently offset by opposite movements of growers' prices, or if fluctuations in crop revenue are sufficiently compensated by alternative sources of income, the high yield risk in pepper cultivation suggests research into policy and policy measures that specifically address this component of income risk (e.g. by more irrigation, use of water saving techniques, etc.).

In Table 2 we have presented a breakdown of the coefficient of variation of yield by holding size. Controlling for the number of vines increases the size of the risk. There is some indication that risk is lower if only 3 years of data are used, which is possibly due to the recall character of the data from crop years 1995-96 and 1996-97. It is difficult to identify a systematic pattern in the size of risk, by the size of holdings. If we focus on median values and data from crop years 1997/98-99/00 (less use of low quality recall data), the table suggests that the extent of the risk is larger for smaller sized farms than for medium sized farms.

Table 2

Coefficient of variation of output and output per vine: Micro evidence

Holding size in acres	OUTPUT		OUTPUT PER VINE	
	1995/96-1999/00 (5 crop years)	**1997/98-1999/00 (3 crop years)**	**1995/96-1999/00 (5 crop years)**	**1997/98-1999/00 (3 crop years)**
0 – 2				
Average	43.6% (0.029)	44.6% (0.046)	51.5% (0.040)	46.8% (0.041)
Median	40.2% (0.027)	41.6% (0.032)	41.0% (0.031)	43.3% (0.048)
2 – 5				
Average	44.6% (0.021)	38.7% (0.024)	45.3% (0.017)	47.5% (0.041)
Median	40.0% (0.023)	34.6% (0.041)	40.3% (0.012)	39.3% (0.021)
> 5				
Average	46.9% (0.035)	39.0% (0.029)	49.7% (0.026)	42.8% (0.035)
Median	39.2% (0.033)	34.1% (0.025)	41.3% (0.031)	33.9% (0.040)

Bootstrapped standard deviation in brackets next to the CVs; number of households: 61 (0-<2acres), 111 (2-<5 acres) and 78 (>=5 acres); Source: Spices Board India, Cochin and ESI-VU, Amsterdam, The Netherlands

5.3.Variation in crop revenue: do prices automatically stabilise revenues?

From a welfare perspective, yield or output risk as such is of limited importance to the individual farmer. The major concern to an individual farmer is the variation in his total income or perhaps, if a large share of total income comes from crop cultivation – the variation in crop revenues. Since agricultural policy is often developed along commodity lines and since the farmers in our survey are primarily pepper growers, we proceed by investigating in the first place variation of revenue from pepper.

As noted above, the components of revenue uncertainty - crop (yield) uncertainty and price uncertainty - may in certain circumstances be mutually offsetting if. For example, a crop shortfall in a major producing country is associated with a rise in the world price of the commodity. It is most likely that this situation characterises the position of Indian pepper farmers: The sheer size of Indian pepper supply on the world market (see Section 3 above) suggests that yield and price uncertainty cannot reasonably be assumed to be independent sources of risk for Indian pepper growers. Empirically it is interesting to investigate how variation in yield and variation in price compares with variation in revenue and, consequently, to what extent automatic insurance takes place.

We investigate this by calculating the variation in revenues from pepper cultivation. A number of conceptual issues need to be resolved in the construction of the crop revenue data[10]. The result of the calculation of variation in crop revenue, shown in Table 3, also report the breakdown of the CVs of crop revenue by holding size.

Table 3

Coefficient of variation of calculated real crop revenue: Micro evidence

Holding size in acres	**REVENUE**		**REVENUE PER VINE**	
	1995/96-1999/00 5 crop years	**1997/98-1999/00 3 crop years**	**1995/96-1999/00 5 crop years**	**1997/98-1999/00 3 crop years**
0 – 2				
Average	52.4% (0.026)	48.3% (0.038)	54.2% (0.038)	49.3% (0.044)
Median	49.6% (0.015)	44.0% (0.039)	51.3% (0.021)	46.9% (0.027)
2 – 5				
Average	52.1% (0.020)	39.5% (0.022)	52.2% (0.029)	42.0% (0.028)
Median	49.6% (0.033)	34.7% (0.025)	50.5% (0.037)	42.7% (0.030)
> 5				
Average	60.6% (0.035)	40.7% (0.033)	61.2% (0.033)	45.3% (0.039)
Median	53.7% (0.019)	35.6% (0.033)	54.1% (0.026)	39.7% (0.049)
All growers				
Average	54.8% (0.017)	42.0% (0.016)	55.5% (0.019)	44.8% (0.024)
Median	50.8% (0.019)	38.2% (0.024)	52.2% (0.013)	41.6% (0.030)

Bootstrapped standard deviation in brackets next to the CVs; number of households: 61 (0-<2acres), 111 (2-<5 acres) and 78 (>=5 acres), 250 (all growers); State wise consumer price indices for agricultural labourers are used to convert revenue into constant prices; Source: Spices Board India, Cochin and ESI-VU, Amsterdam, The Netherlands.

From Table 3 we observe an even more clear increase in the size of the risk if one controls for the number of vines. Again, risk appears to be lower if only 3 years of data are used. Inspection of the development of (real) prices suggest that this is most likely due to the smaller year to year variation in prices for this period. Differences become

[10] Actual revenues of pepper are also recorded in the survey. However, since these sales are influenced by the storage behaviour of the individual (see also Zant (2004)), variation in these sales are not particularly representative of output risk. Hence, we have calculated potential revenues by multiplying the harvested quantity by the unit value realised by the individual farmer. In case no sales have been made in the entire season we have imputed the average unit value realised in the block. For the crop years 1995/96, 1996/97 and 1997/98, we lack data on per kg unit values of sales. We have dealt with this problem by using an appropriate fixed proportion of monthly market prices, taking account of the regional seasonal pattern in sales of farmers, available for the crop years 1998/99 and 1999/2000. This appears to be a reasonable assumption in view of the experience of the crop years 1998/99 and 1999/00 (see also appendix).

substantial with larger sized holdings. The table suggests that the size of the revenue risk is larger for smaller sized farms than on medium and larger sized farms, if we focus on data from crop years 1997/98-99/00, and this is slightly more pronounced than in the case of output.

The value of the CV of revenue for all pepper growers in bottom line in Table 3, is higher than the corresponding CVs for yield (see Table 1): it increases from an average (median) value of 45.1% (39.7%) for yield to 54.8% (50.5%) for revenue. The average (median) CV for real pepper prices for the corresponding period – 1995/96 to 1999/2000 - is 28.4% (27.3%). It is tempting to compare the CV of revenue with sum of the independently calculated CVs of production and output and attribute the difference to automatic stabilisation: Instead of CVs in the order of 68-81% - the sum of separately calculated yield variation and price variation – CV of revenues have values between 55-59%. However, we prefer to calculate the exact extent of automatic stabilisation with the help of equation (6), where the variance of revenue is expressed in terms of the variance and covariance of its two underlying components, price and output. Calculation on the basis on this expression makes clear that the extent of automatic stabilisation is very modest: the automatic stabilisation only reduces the CV of revenue with a few percentage points (for the period 1995/96 to 1999/2000 it reduces from 55.5% (49.5) to 52.2% (47.2), and for the period 1997/98 to 1999/2000, from 45.1% (40.9) to 43.9% (40.1). It should be mentioned at this point that this result is due to the data at hand: other periods and other crops may show different outcomes.

5.4. Variation of consumption expenditure of pepper growers

To what extent does the variation in crop revenue have an impact on consumption? Consumption expenditure is recorded in the survey by asking pepper growers the market value of their last month consumption expenditures[11]. Consumption expenditure data have been deflated with the consumer price index for agricultural labourers, specified by state (in our case Kerala, Karnataka and Tamil Nadu)[12]. The survey data also allow a

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[11] The question in the questionnaire on consumption is: "Could you give a breakdown of the last month money value of your consumption expenditure?". We are aware that this "self reported" data on consumption expenditure contains a potential arbitrary element and is conceptually remote from the techniques applied in poverty assessments of the World Bank to estimate total household consumption (see e.g. Deaton (1992)). However, the consumption expenditure is reported on a monthly basis and since this reduces the 'recall' property of the reply, part of the arbitrariness is limited. More detailed questions on the various components of consumption of pepper growers were beyond the objectives of the survey and could not be implemented.

[12] Monthly series of the consumer price index for agricultural labourers are obtained from the web site of

breakdown of total consumption expenditure in food items and non-food items. This is attractive since variation based on monthly data may be exaggerated due to purchases of consumer durables.

Table 4

Coefficient of variation of real per capita consumption expenditure : Micro evidence

Holding size in acres	Monthly observations	Annualised observations*
0 – 2		
Average	28.9% (0.036)	14.3% (0.014)
Median	18.7% (0.017)	11.4% (0.013)
2 – 5		
Average	27.0% (0.019)	13.6% (0.009)
Median	19.3% (0.011)	10.2% (0.010)
> 5		
Average	35.7% (0.020)	14.7% (0.011)
Median	30.9% (0.041)	12.6% (0.013)
All growers (per capita total consumption)		
Average	30.2% (0.016)	14.1% (0.006)
Median	21.2% (0.011)	11.2% (0.008)
All growers (per capita food consumption)		
Average	22.9% (0.006)	12.8% (0.006)
Median	21.3% (0.006)	10.8% (0.008)

Bootstrapped standard deviation in brackets next to the CVs; number of households: 61 (0-<2acres), 111 (2-<5 acres) and 78 (>=5 acres), 250 (all growers); State wise consumer price indices for agricultural labourers are used to convert consumption expenditure into constant prices; Source: Spices Board India, Cochin and ESI-VU, Amsterdam, The Netherlands
* On the basis of monthly data on consumption expenditure from April 1998 to August 2000, we have constructed 3 annual consumption expenditure figures per household.

The coefficients of variation in the table are calculated on the basis of monthly and annualised data. Annual data are constructed on the basis of monthly data[13]. We have included variation in annual aggregates because:

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the Reserve Bank of India (http://www.rbi.org.in).

[13] We have observations of consumption expenditure recorded at the end of each month, from April 1998 to August 2000, and hence 28 monthly observations per household. Annual series are constructed by summing up to a twelve month period.

- Using variation in annual consumption expenditure allows comparisons with variation in other annual variables like revenue and other income components.
- occasional outlays in consumer durables exaggerate the variation if calculated on the basis of monthly data.
- by using annualised data we automatically control for seasonal variation.

The coefficients of variation of consumption expenditure, shown in Table 4, make clear that pepper growers are fairly successful in smoothing their consumption expenditure: If compared with the coefficient of variation of revenue, we observe a decrease from 55-59% in crop revenue to less than 15% in consumption expenditure!

Table 5

Cost of risk in pepper cultivation*: Micro evidence

	Value of coefficient of relative risk aversion (R)		
	R=1	**R=2**	**R=3**
Output			
Average	11.6%	23.2%	34.8%
Median	8.6%	17.2%	25.8%
Revenue			
Average	17.5%	35.0%	52.6%
Median	15.4%	30.8%	46.2%
Per capita total consumption			
Average	1.0%	1.9%	2.9%
Median	0.7%	1.3%	2.0%

* The cost of risk is calculated as C(risk) = ½ . R . σ^2, where R = the coefficient of relative risk aversion and σ = the coefficient of variation.

It should be noted that the coefficient of variation enters utility in a quadratic form. As a result the cost of risk measured by the variation of consumption expenditure is negligible, while it is substantial in the case of crop revenue. These assertions are summarised in Table 5, where we have presented the cost of yield risk, revenue and consumption expenditure, assuming a plausible range of values of the coefficient of relative risk aversion.

Another perspective to assess the figures in Table 5 is to evaluate them in terms of willingness to pay. The table quantifies what households are prepared to pay for a crop index insurance in order to eliminate variability in crop revenue completely. The imputed coefficients of relative risk aversion are in the range that is found in empirical work elsewhere: these values are believed to be realistic and relevant. Consequently, households are prepared to give up a minimum of 15.4% of revenues to have their pepper revenues completely insured. Alternative mechanisms that smooth consumption may already be operational. Such arrangements would lower the willingness to pay for a formal insurance. However, in this case, and last but not least, the relative cost effectiveness of these other mechanisms should be considered. Investigation of these issues is beyond the scope of this paper (see Zant (2004)).

6. Summary and conclusion

The outcome of our empirical work suggests that yield risk is high and of a comparable size to price risk: yield risk in Indian pepper cultivation is a substantial component of revenue risk. Policy measures designed to reduce revenue uncertainty should take account of this result and should address the yield risk component of revenue risk, in addition to the price risk component, or address revenue risk instead. Revenue risk is larger than yield risk, but less than the sum of yield risk and price risk if assessed independently. One may be tempted to attribute the difference to automatic stabilisation, the offsetting movements of prices and quantities. However, automatic stabilisation is very modest. Despite this substantial variation in revenues, pepper growers are shown to have effectively smoothed total consumption expenditures. Willingness to pay for revenue insurance is most likely very considerable.

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Appendix

Figure A1 Variance of relative price changes of Indian pepper: macro evidence (monthly data, January 1980- December 1999)

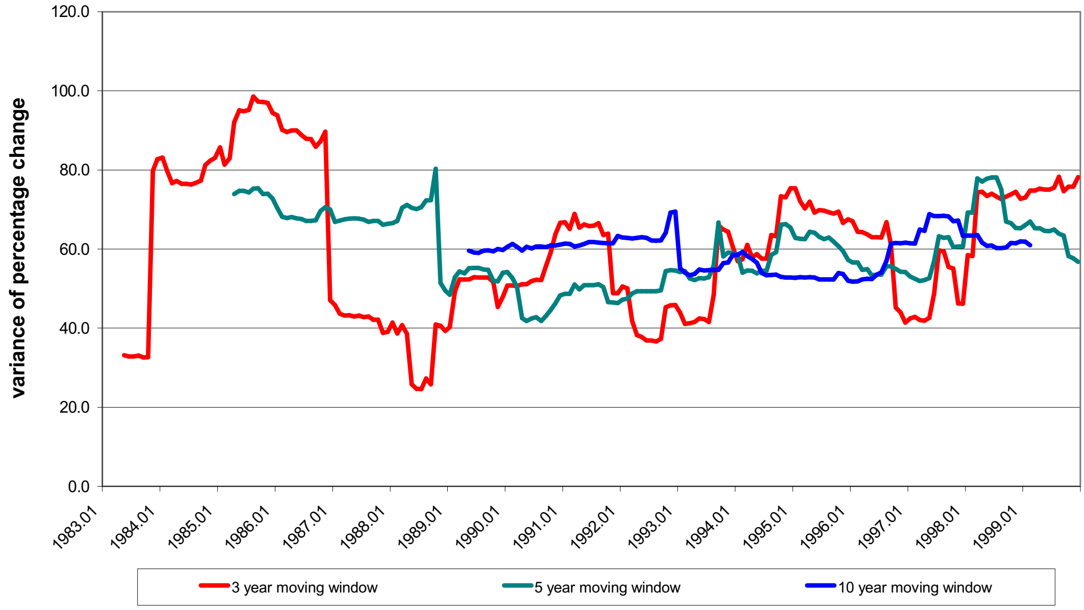

Figure A2 Official market prices and growers' prices obtained from survey

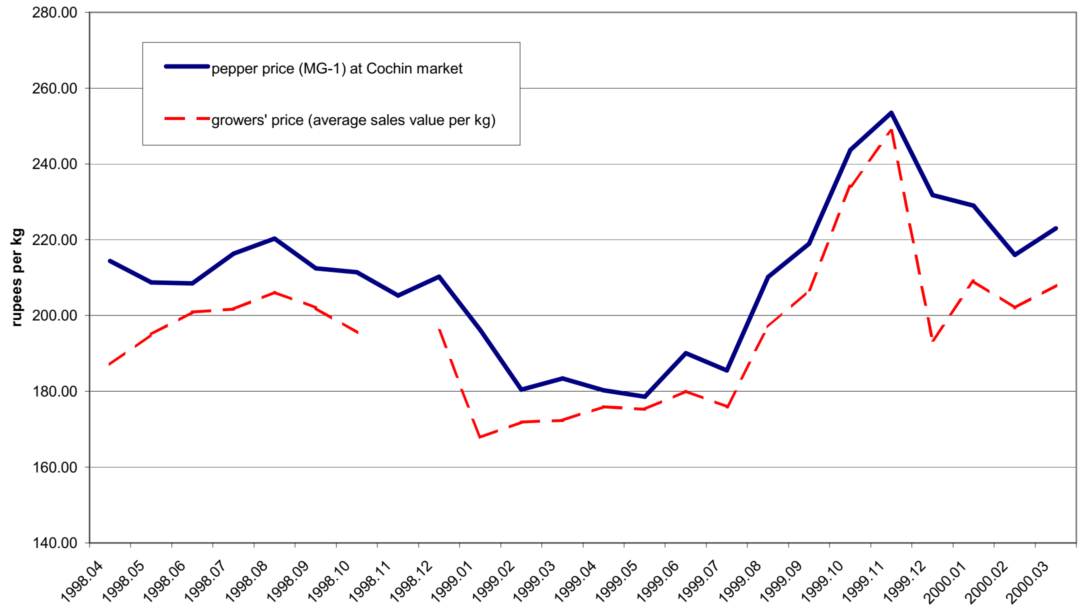

Table A3 Size of holdings and number of bearing vines

	Size of holding in acres										
Number of bearing vines	**<1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-7.5**	**7.5-10**	**10-15**	**15-50**	**>50**	
0-<=100	4.3%	3.0%	2.1%		0.4%	0.4%	0.4%				10.7%
100-<=200	3.0%	3.0%	1.7%	0.4%		1.7%	0.4%	1.3%			11.5%
200-<=300	3.0%	4.3%	1.3%	0.9%		0.4%	1.3%				11.1%
300-<=400	2.1%	2.6%	1.7%	1.7%	2.6%	1.3%	0.9%		0.4%		13.2%
400-<=500	1.3%	1.7%	2.1%	1.7%	0.9%	0.9%			0.4%		9.0%
500-<=600	1.3%	0.9%	2.1%	0.4%	0.9%	0.9%					6.4%
600-<=800	0.4%	2.1%	1.7%	2.6%	1.7%	1.3%		1.3%			11.1%
800-<=1000		2.6%	0.9%	1.7%	1.3%	0.9%	0.9%	0.4%			8.5%
1000-<=2000				4.3%	1.3%	0.9%	0.4%	1.7%	0.9%	0.4%	9.8%
>2000				0.4%	0.4%	0.4%	0.9%	0.9%	3.0%	2.6%	8.5%
	15.4%	20.1%	13.7%	14.1%	9.4%	9.0%	5.1%	5.6%	4.7%	3.0%	100%

Figure A4 Frequency distribution of coefficients of variation of output per vine (all pepper growers)